Changes to the International Standard for Industrial PRT's (IEC 60751 Ed.2 2008)

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Abstract

The International Standard that specified Industrial PRT's since 1983 has been IEC 751.

The 2008 Edition attempts to clarify the differences between Platinum Wire Wound Resistors and Plat-Film substrates it also clearly separates assemblies (or thermometers) from the sensing element.

In this summary of the new standard the tolerances of the old and new standard are presented graphically rather than tabulated algebraically for clarity.

Other major aspects are also described, such as immersion testing and Hysteresis.

Who should attend?

Everyone involved in making or using industrial temperature measurements.

1. Introduction

IEC 751 describes Industrial Platinum Resistance Thermometer Sensors. The Standard covers thermometers suitable for all or part of the temperature range -200ºC to +850ºC with two tolerance classes.

It is primarily concerned with sheathed elements suitable for immersion in the medium whose temperature is to be measured.

Methods of test to prove compliance with this standard and suitable apparatus for some of the tests are also described.

IEC 60751 Ed.2 2008 introduces several significant technical changes with respect to the previous edition.

1.1 Whilst the Resistance/Temperature relationship remains unchanged tolerance classes follow a new scheme.
1.2 A tolerance acceptance test is included
1.3 Several changes are made to individual tests
1.4 The standard differentiates between the sensing resistor and the complete thermometer

2. Key Definitions

2.1 Platinum Resistor – A resistor made from a platinum wire or film with defined electrical characteristics embedded in an insulator and designed to be assembled into a resistance thermometer. Sometimes called PRT's, Pt100's, Platinum Sensing Element.

2.2 Platinum Resistance Thermometer (PRT) – A temperature response device consisting 1 or more platinum resistors within a protective sheath, internal connecting wires and external terminals.

Other definitions can be found in IEC 60751 [1].

The standard continues to use the Callendar-van-Deuson equations as follows;-

-200ºC to 0ºC
$Rt = Ro\ [1+At+Bt^2+c\ (t-100ºC)t^3]$
0ºC to 850ºC
$Rt = Ro\ (1+At+Bt^2)$
Rt = Resistance at temperature t
Ro = Resistance at t=0ºC
$A = 3.9083 \times 10^{-3}\ ºC^{-1}$
$B = -5.775 \times 10^{-7}\ ºC^{-2}$
$C = -4.183 \times 10^{-12}\ ºC^{-4}$

2.3 Tolerances – The temperature ranges are based on working experience with film and wire resistors.

The following graphs show:

1. Tolerances Class A and Class B from IEC 751, 1983
2. Tolerances for Wire Wound Platinum Resistors IEC 60751, 2008
3. Tolerances for Plat Film Resistors IEC 60751, 2008
4. Tolerances for Thermometers containing Wire Resistors
5. Tolerances for Thermometers containing Film Resistors

2.4 Special Tolerances – Can be agreed between manufacturer and user. Tolerance should be constructed as a multiple or fraction of the Class B tolerances

Graph 1 - Thermometer Tolerances IEC 60751 & IEC 751 (1983)

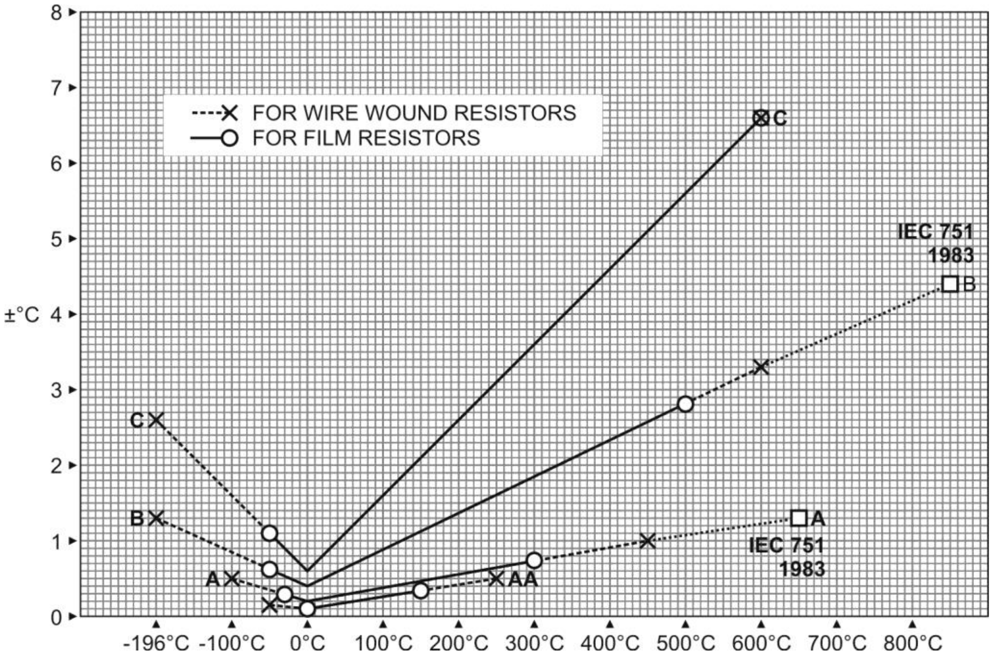


Table 1 - Tolerance Classes for Thermometers

Tolerance Class	Temperature Range of Validity ºC		Tolerance Values[a]
	Wire Wound Resistors (x)	**Film Resistors (o)**	
AA	-50 to +250	0 to +150	±(0.1 + 0.0017 ǀ t ǀ)
A	-100 to +450	-30 to +300	±(0.15 + 0.002 ǀ t ǀ)
B	-196 to +600	-50 to +500	±(0.3 + 0.005 ǀ t ǀ)
C	-196 to +600	-50 to +600	±(0.6 + 0.01 ǀ t ǀ)
[a] ǀ t ǀ = modulus of temperature in ºC without regard to sign			

NB. Thermometers above 600ºC are no longer covered by IEC 60751

Graph 2 - Platinum Wire/Film Resistor Tolerances IEC 60751

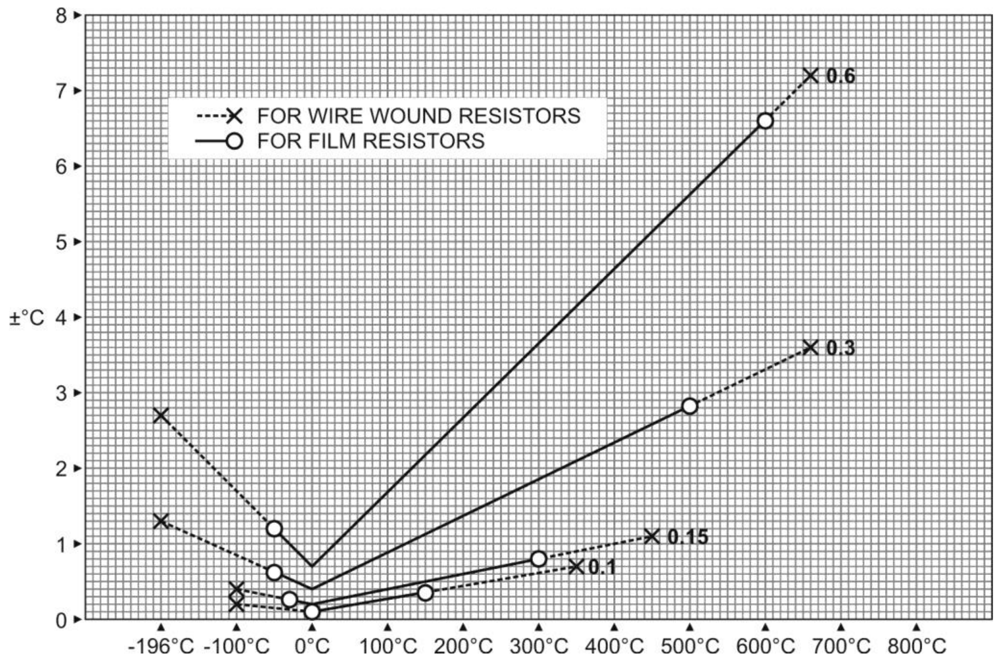


Table 2 - Tolerance Classes for Resistors

For Wire Wound Resistors (x)		Film Resistors (o)		Tolerance Values[a] °C
Tolerance Class	**Temperature Range of Validity ºC**	**Tolerance Class**	**Temperature Range of Validity ºC**	
W 0.1	-100 to +350	F 0.1	0 to +150	±(0.1 + 0.0017 ׀ t ׀)
W 0.15	-100 to +450	F 0.15	-30 to +300	±(0.15 + 0.002 ׀ t ׀)
W 0.3	-196 to +600	F 0.3	-50 to +500	±(0.3 + 0.005 ׀ t ׀)
W 0.6	-196 to +600	F 0.6	-50 to +600	±(0.6 + 0.01 ׀ t ׀)
[a] ׀ t ׀ = modulus of temperature in ºC without regard to sign				

3. Testing is a big part of the new standard. It falls into two types.

1. Routine Production Testing
2. Type Tests

The table below summarises the tests for resistors and thermometers

Table 3 - Table of tests described in this standard

	Routine Production Tests		**Type Tests**		**Additional Type Tests**
	Resistors	**Thermometers**	**Resistors**	**Thermometers**	
Resistance tolerance	6.2.1	6.3.4	6.4.1	6.3.4	
Insulation resistance at ambient temperature		6.3.1		6.3.1	
Sheath integrity test		6.3.2		6.3.2	
Dimensional test		6.3.3		6.3.3	
Stability at upper temperature limit			6.4.2	6.5.3	
Thermoelectric effect				6.5.4	
Self-heating			6.4.3	6.5.7	
Insulation resistance at elevated temperatures				6.5.1	
Thermal response time				6.5.2	
Effect of temperature cycling				6.5.5	
Hysteresis				6.5.6	
Minimum immersion depth				6.5.8	
Capacitance					6.6.1
Inductance					6.6.2
Dielectric strength					6.6.3
Vibration Test					6.6.4
Drop Test					6.6.5

In my opinion there are two key tests without which a resistor/thermometer may not function correctly.

3. Hysteresis

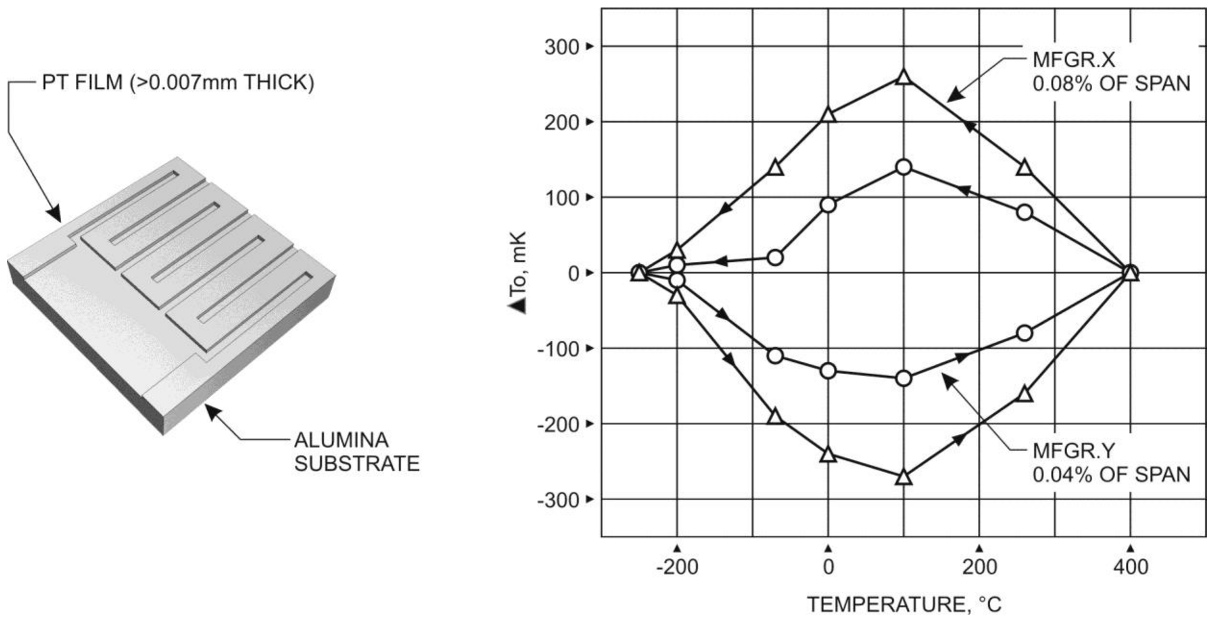
Most of us are familiar with Hysteresis in liquid-in-glass thermometers. They read lower when the temperature is increasing and higher when the temperature is decreasing due to capillary effects.

The adhesives used inside a Platinum Resistor all create Hysteresis curves of various type of resistor [3].

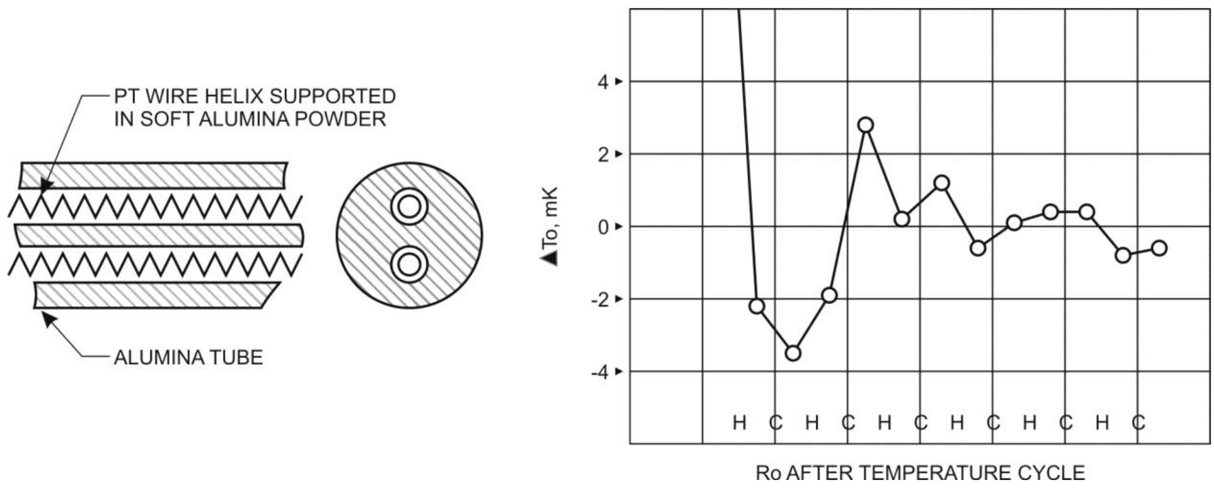
Hysteresis as large as large 0.6ºC can exist, or as small as 0.002ºC.

As a user make sure you know what is inside your thermometer.

Graph 3 - Hysteresis effects in Thin Film Platinum Resistors



Graph 4 - Resistor design exhibiting low Hysteresis. For more information on low Hysteresis Platinum Resistors go to Thermal Developments International at www.t-d-i.co.uk.



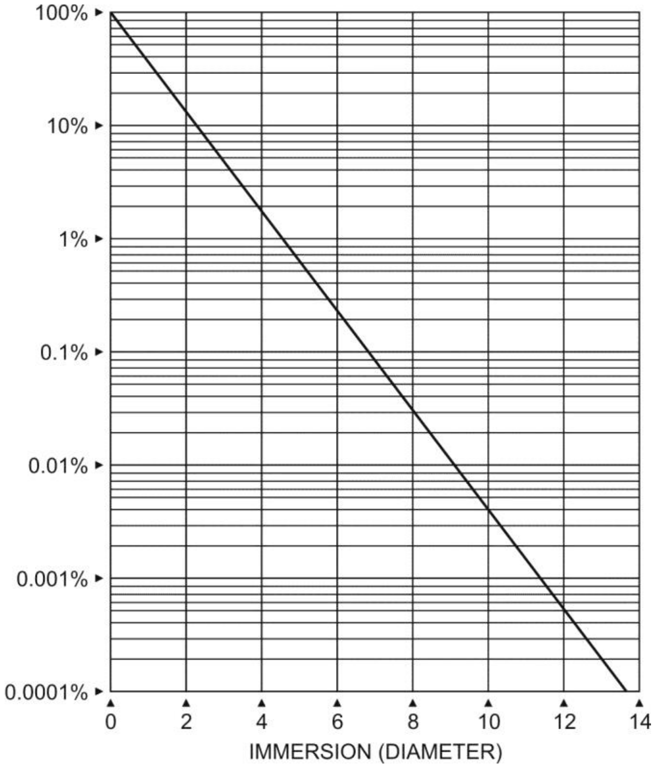
4. **Immersion** – A Thermometer measures its own Temperature. It will only measure the temperature you are interested in **PROVIDED** it is sufficiently immersed.

Here are two guidance charts – one for thermometers in air, the other in stirred liquid.

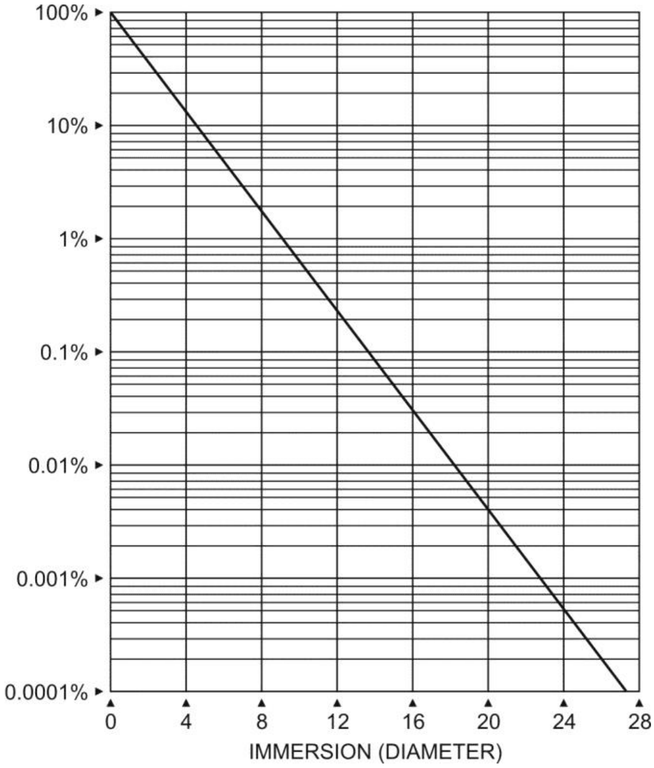
The only real way to know is to withdraw the thermometer 2 or 3 diameters; the reading should not change [2].

For more information go to Thermal Developments International at www.t-d-i.co.uk.

Graph 5 - The relative temperature error [$\Delta T_m/T_{sys}-T_{amb}$] plotted against thermometer immersion depth in diameters. This graph is appropriate to sensors in stirred liquid baths.



Graph 6 - The relative temperature error [$\Delta T_m/T_{sys}-T_{amb}$] plotted against thermometer immersion depth in diameters. This graph is appropriate to sensors where $D_{eff}/D=2$, such as in a dry block calibrator.



I do not know of a Platinum Thermometer that fully complies with IEC 60751 Ed.2 2008.

Usually, when a supplier says he complies, he means that the Platinum Resistor he has used complies to the Resistance/Temperature characteristics of IEC 60751.

Next time you buy or use, a Platinum Thermometer, find out what is inside and how it is has been tested.

After all, you life could depend on it.

References

[1] IEC 60751 Ed.2 0 2008-07, ISBN 2-8318-9849-8

[2] Immersion Depths, John P. Tavener

[3] Thermal Hysteresis and Stress in PRT's, D. J. Curtis, Temp 1982, P.806